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Rinkewich

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[54] **MULTIPLE-WALL PLASTIC CONTAINER AND METHOD OF MAKING SAME**

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[21] Appl. No.: **600,940**

[57] **ABSTRACT**

[22] Filed: **Oct. 22, 1990**

A high pressure plastic container is made by rotationally moulding a first wall of plastic material, and a second wall enclosing and bonded to the first wall. One of the walls is integrally formed with a plurality of circumferentially-extending axially-spaced ribs of a hollow construction. The other wall may be unribbed, or may be integrally formed with a plurality of axially-extending circumferentially-spaced hollow ribs. The hollow ribs, are filled with a rigid plastic foam.

[51] Int. Cl.⁵ **B65D 6/00**

[52] U.S. Cl. **220/586; 220/469; 220/673; 220/675**

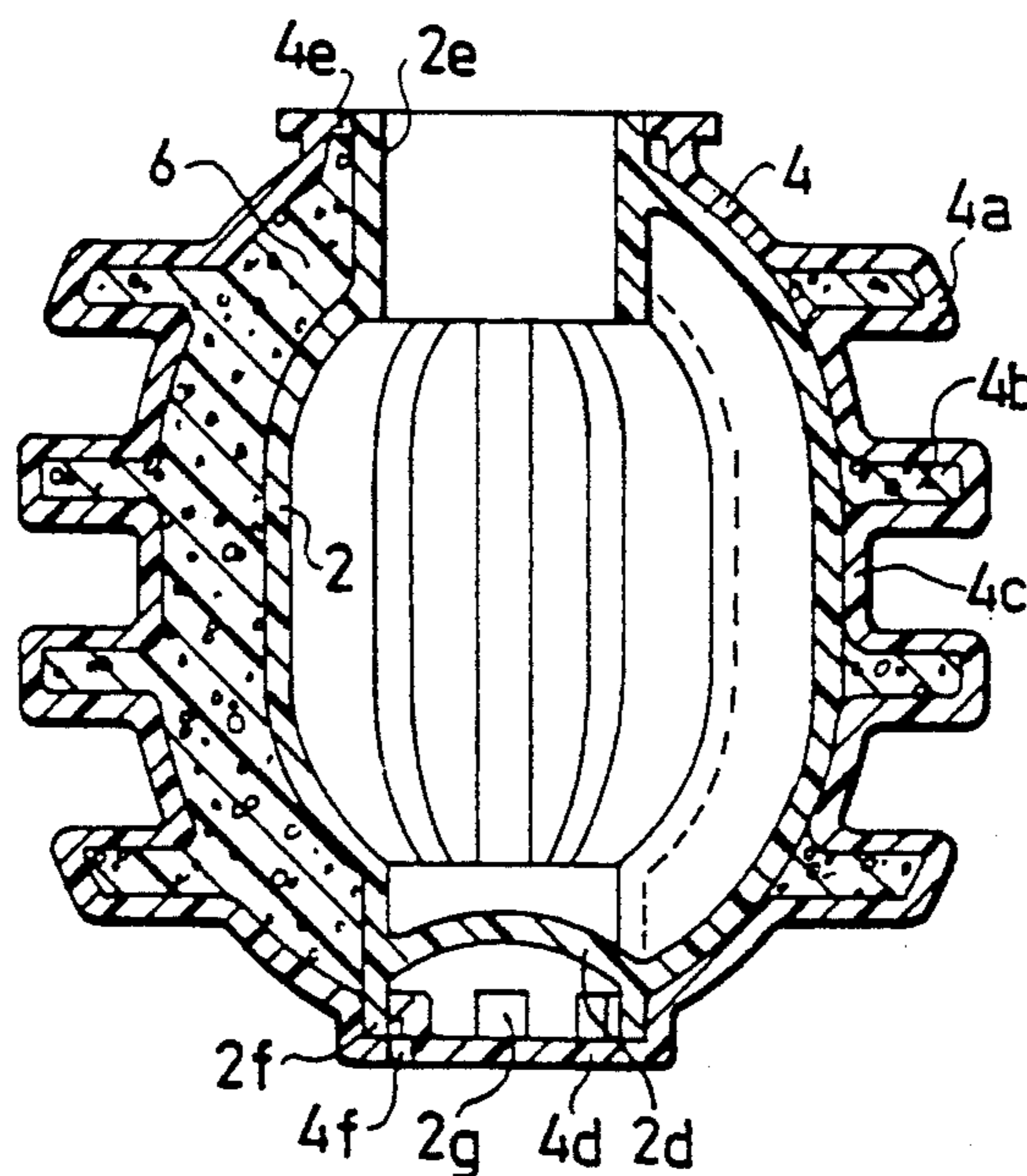
[58] Field of Search **220/3, 444, 469, 671, 220/672, 673, 586, 675**

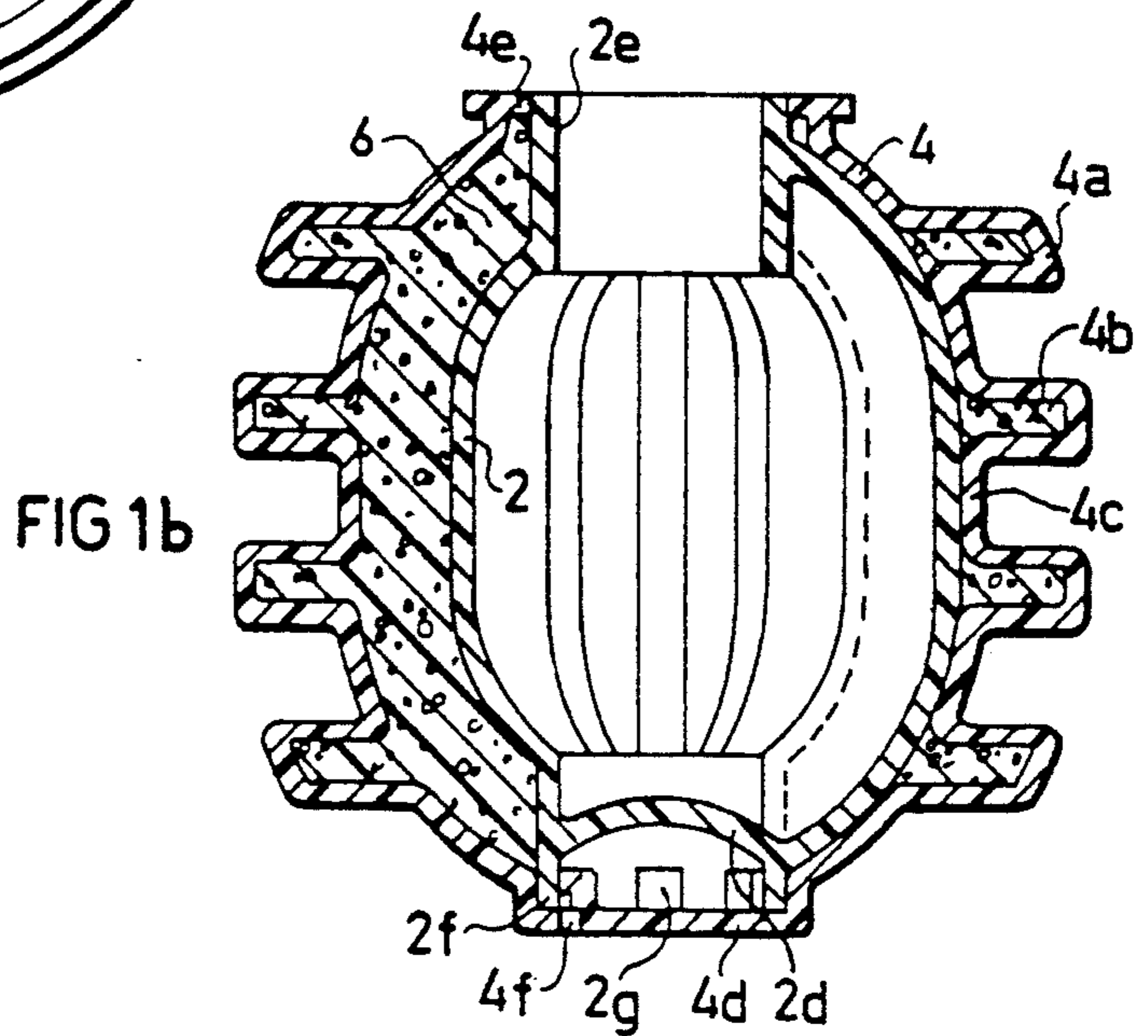
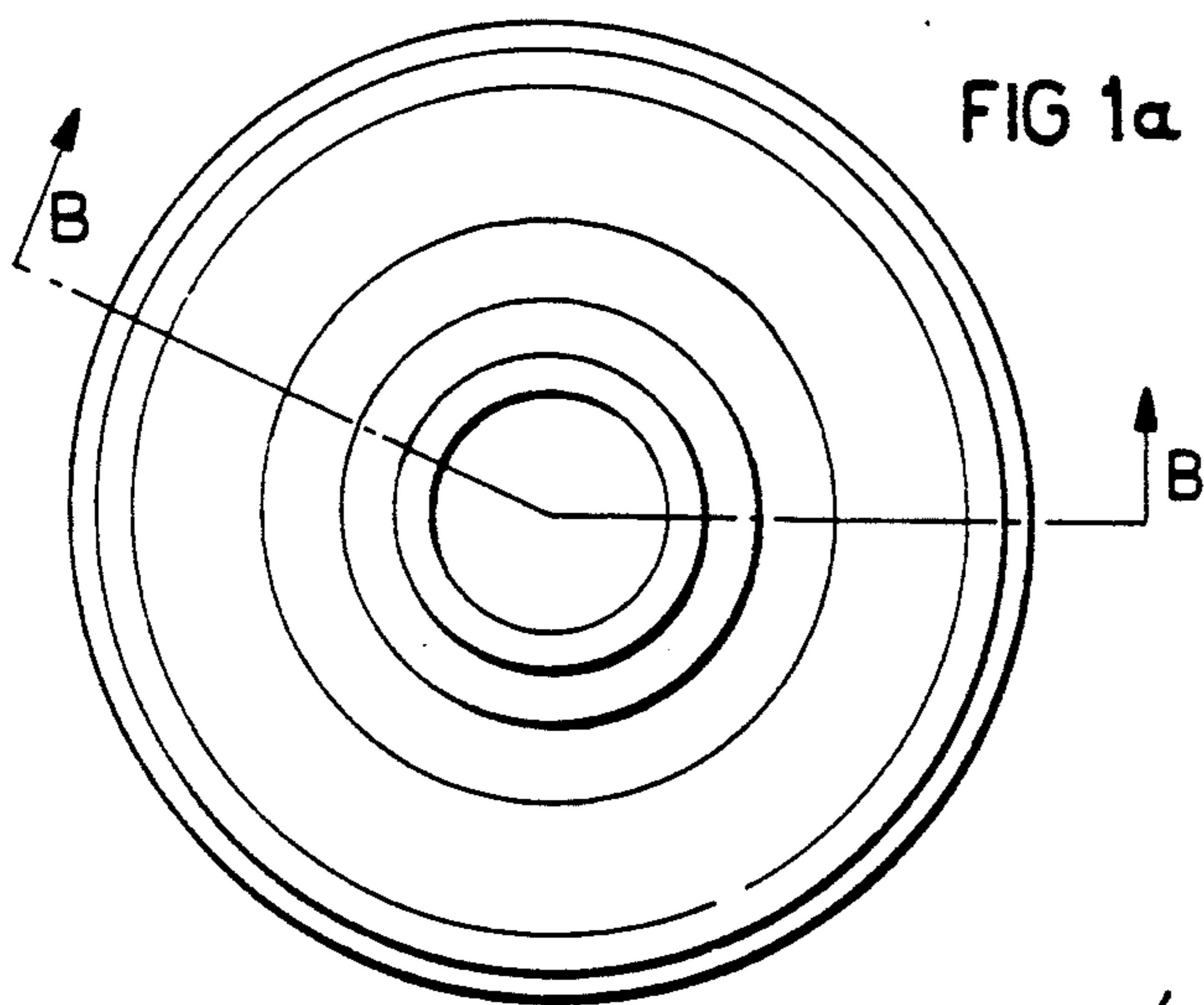
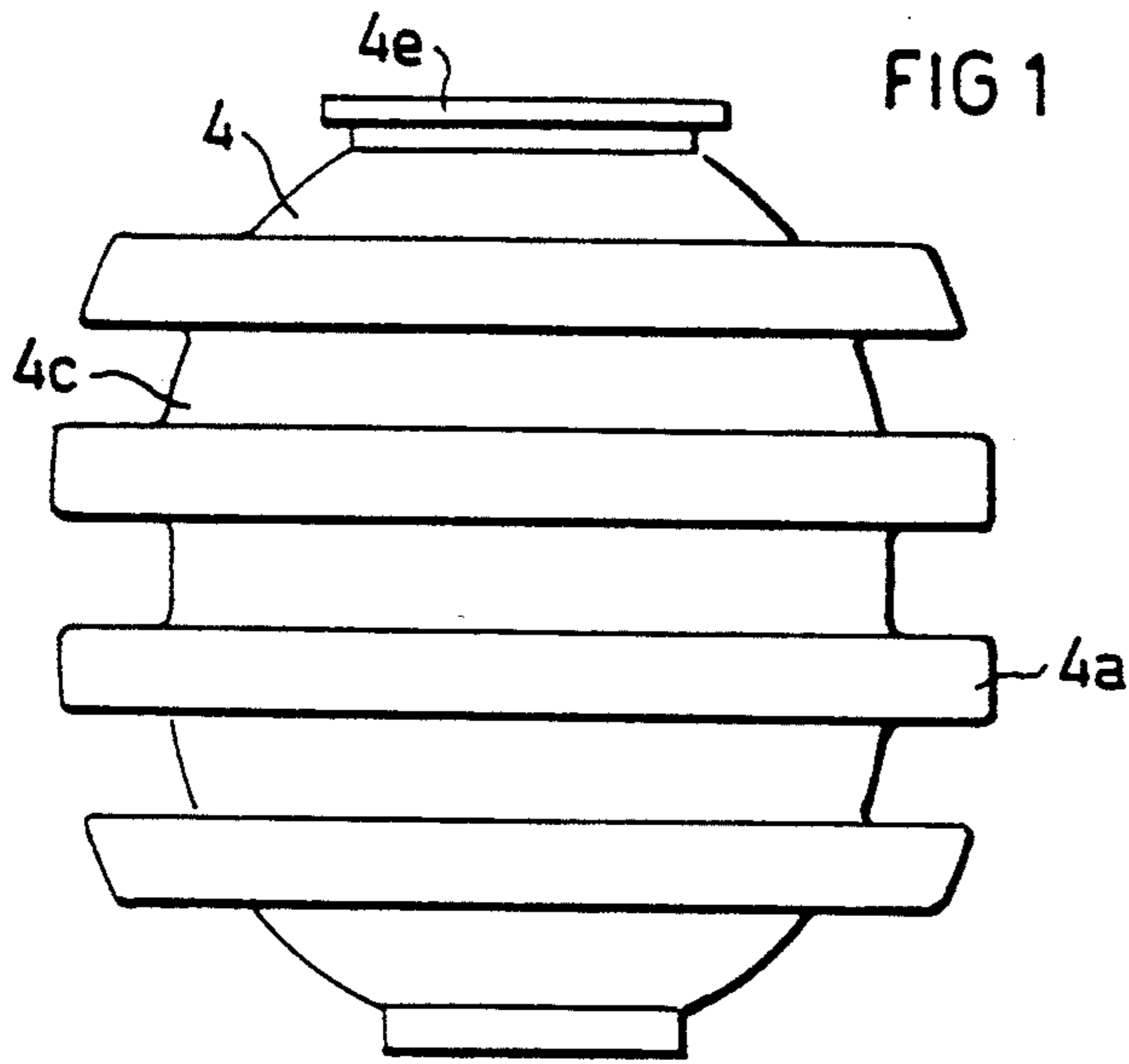
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11 Claims, 6 Drawing Sheets





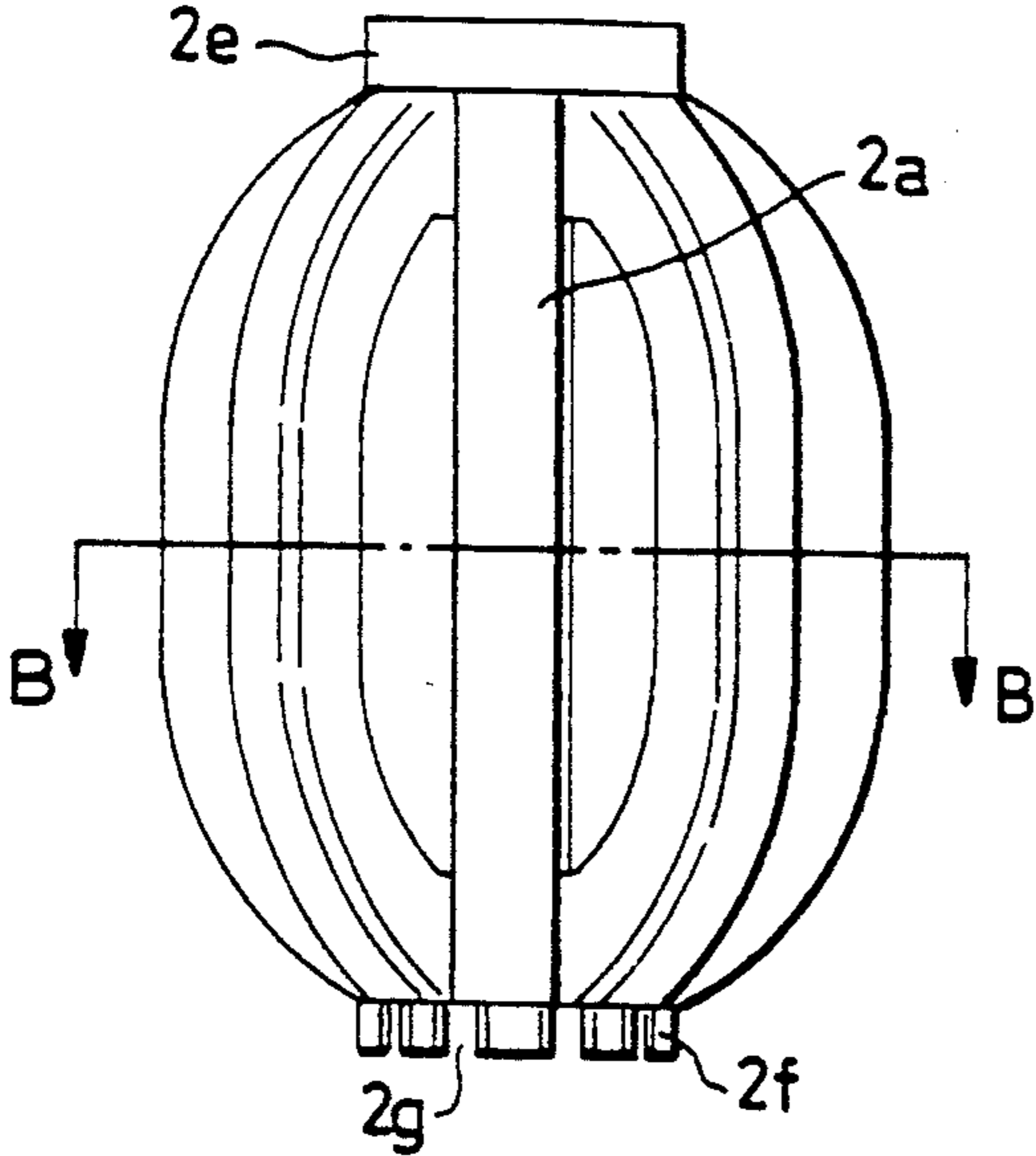


FIG 2

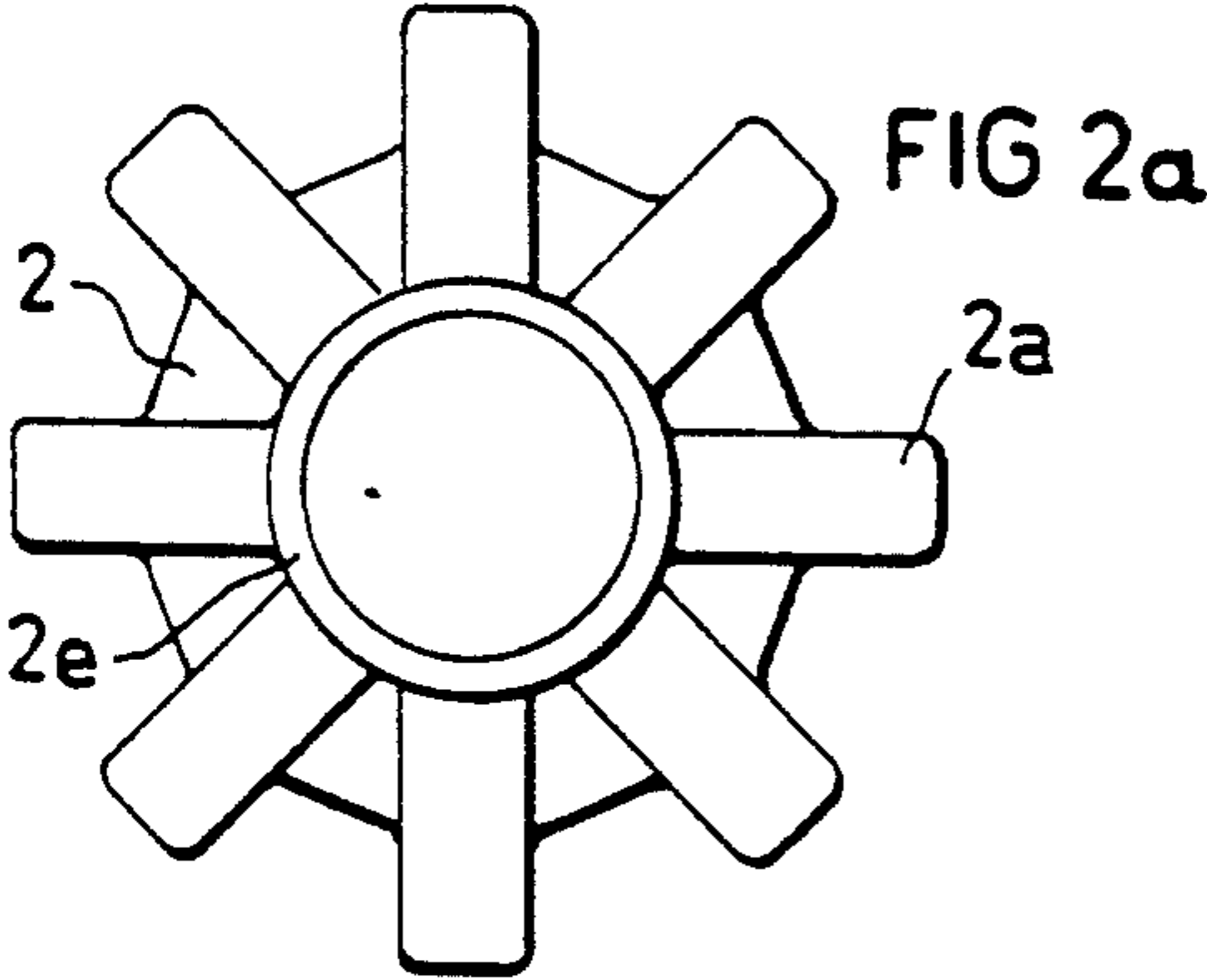


FIG 2a

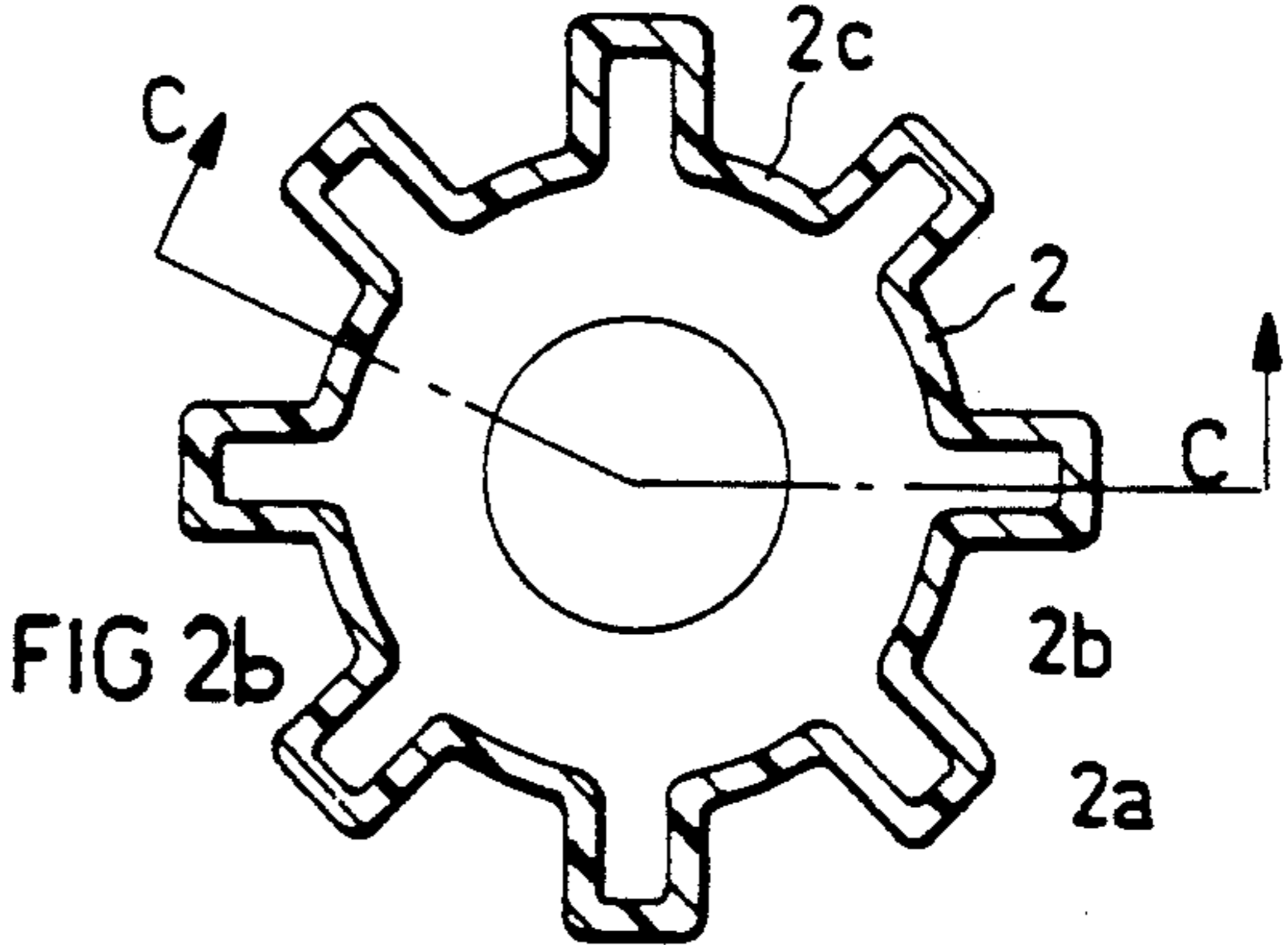


FIG 2b

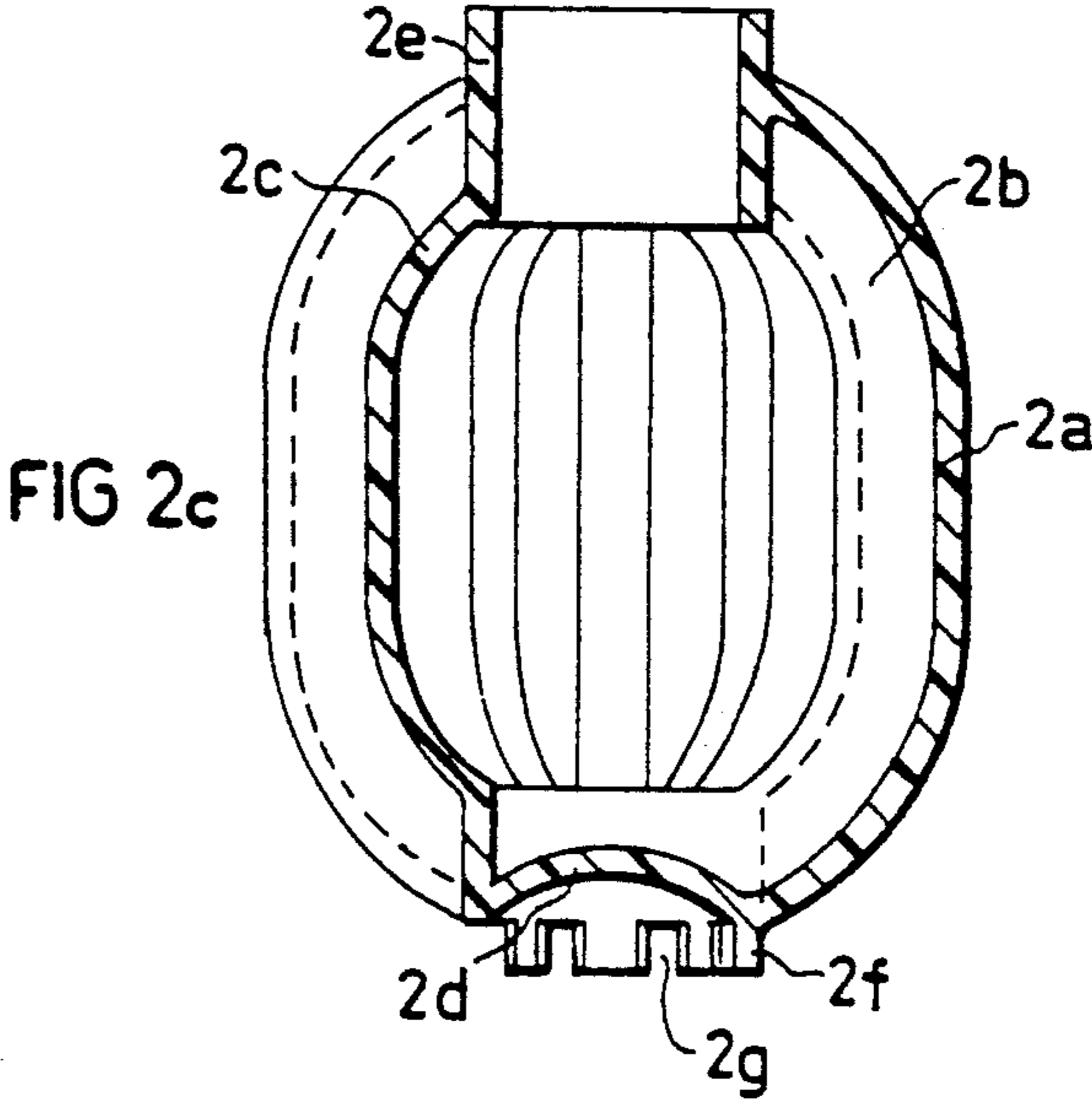


FIG 2c

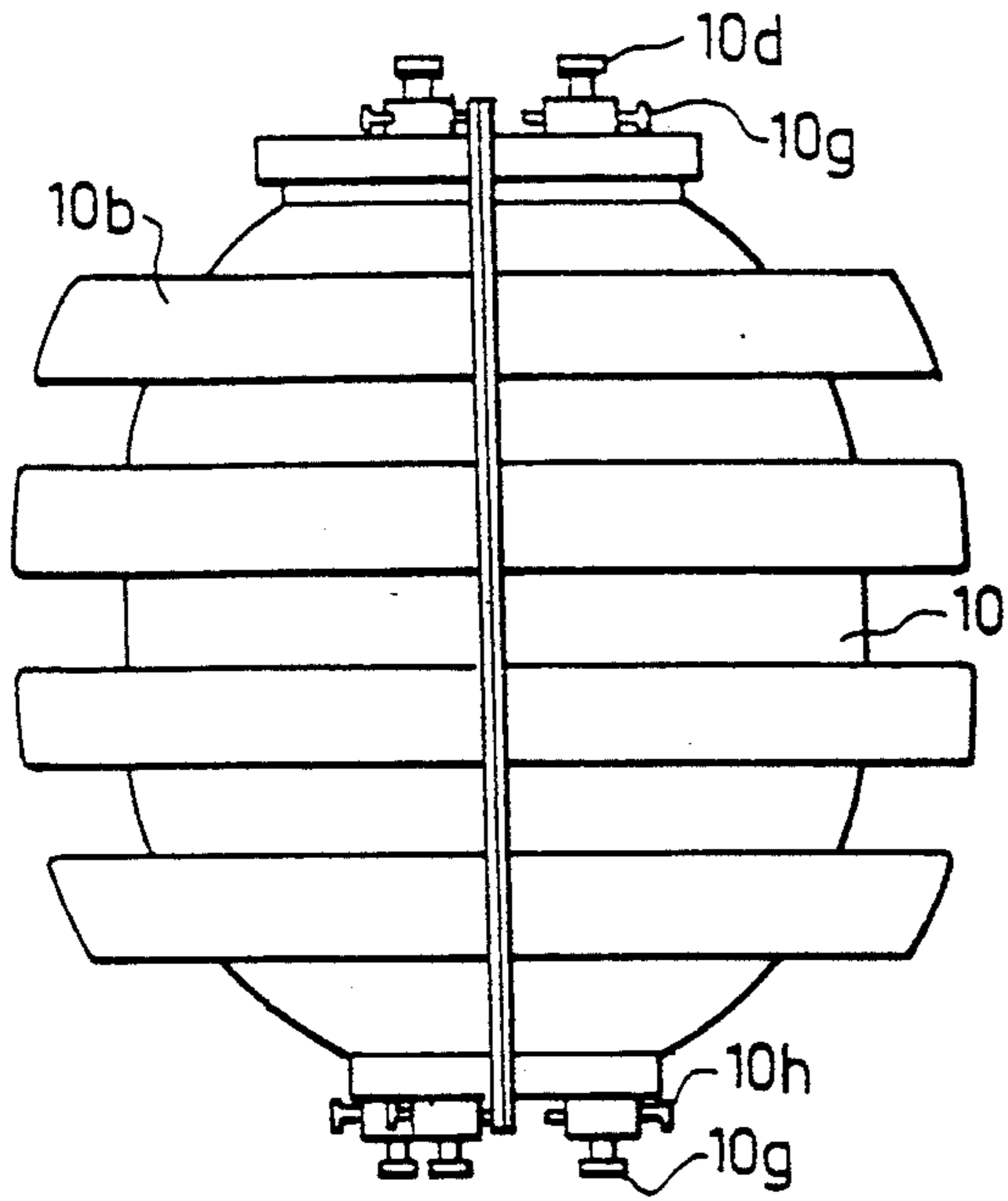


FIG 3

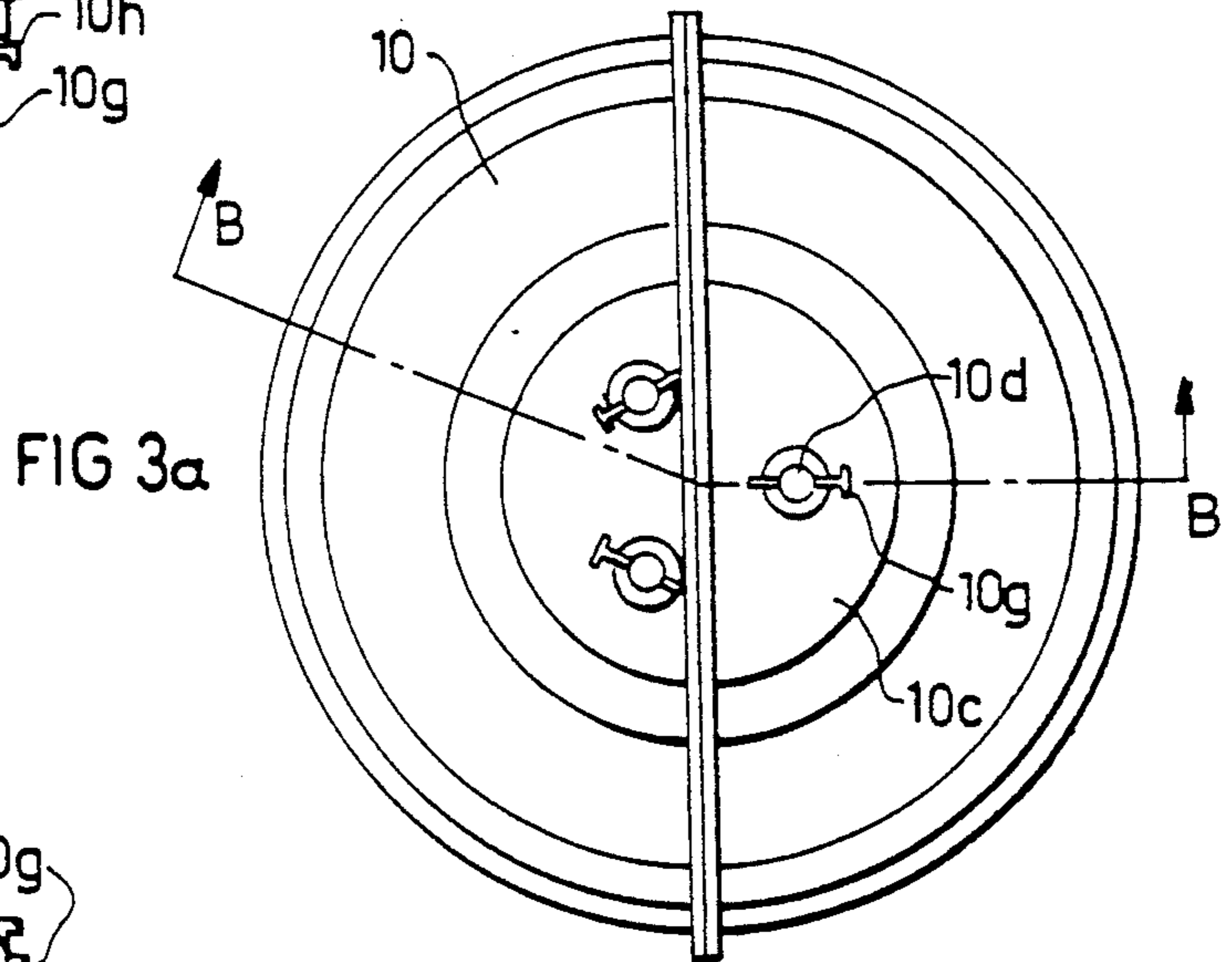


FIG 3a

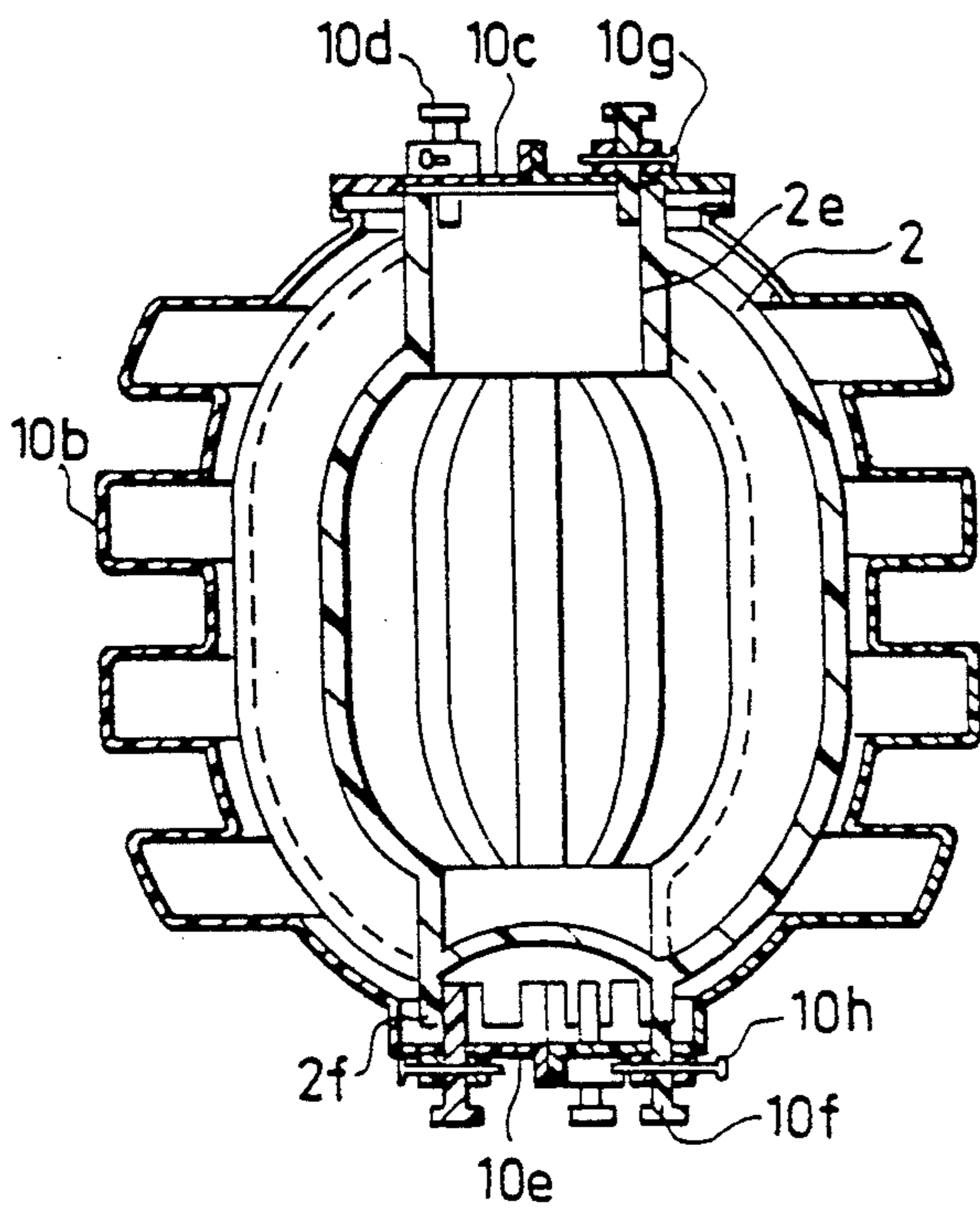


FIG 3b

FIG 4

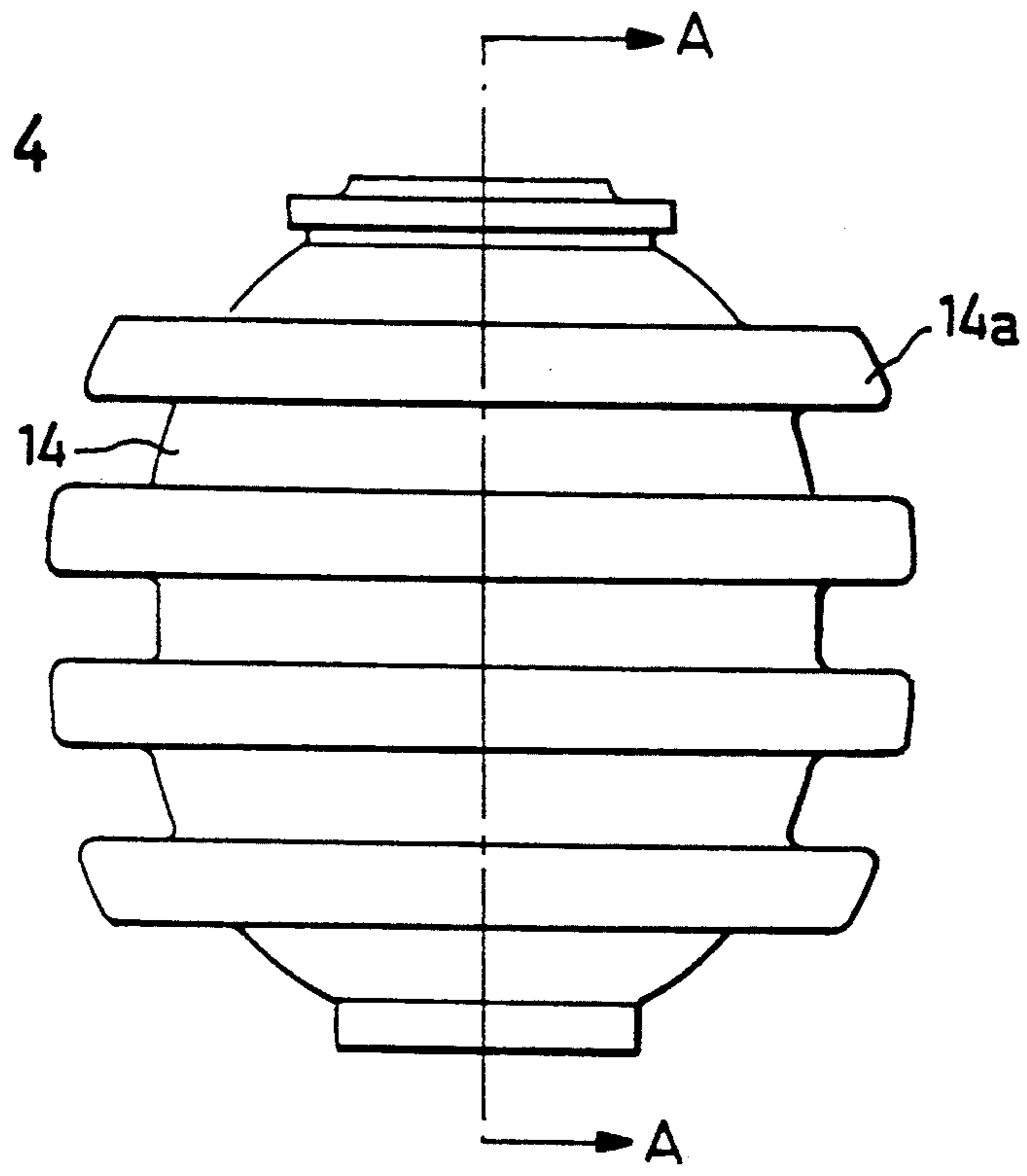
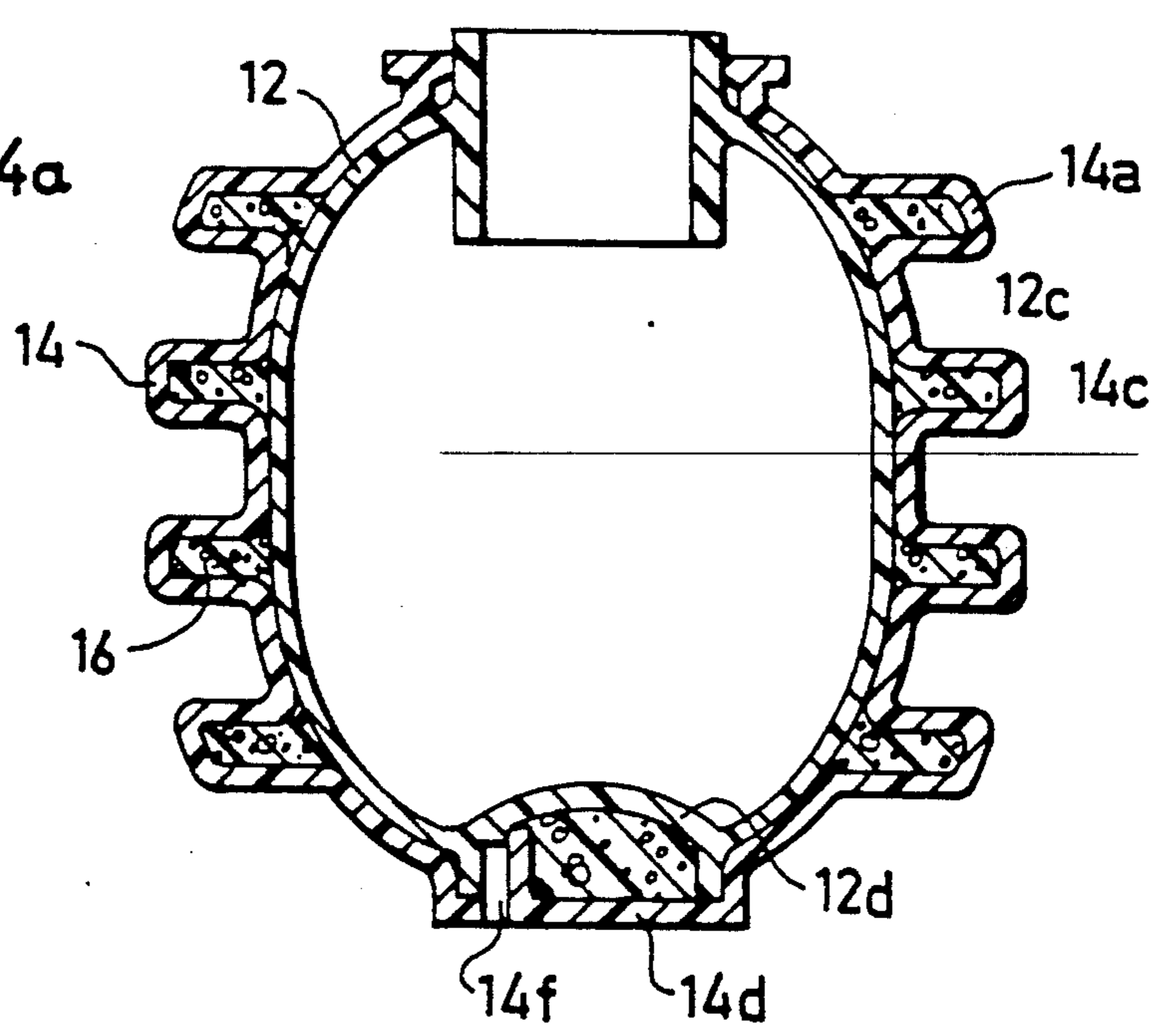
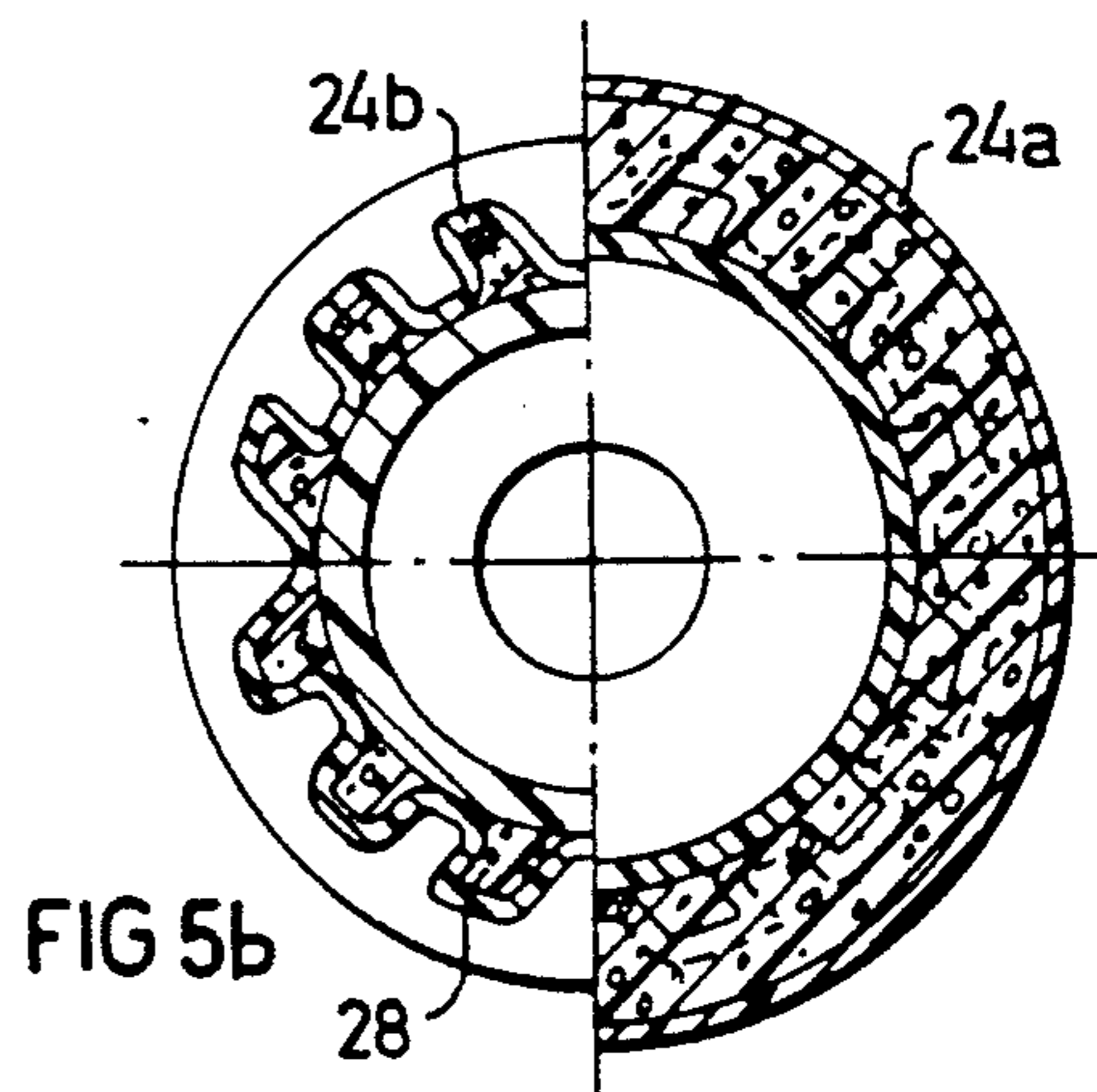
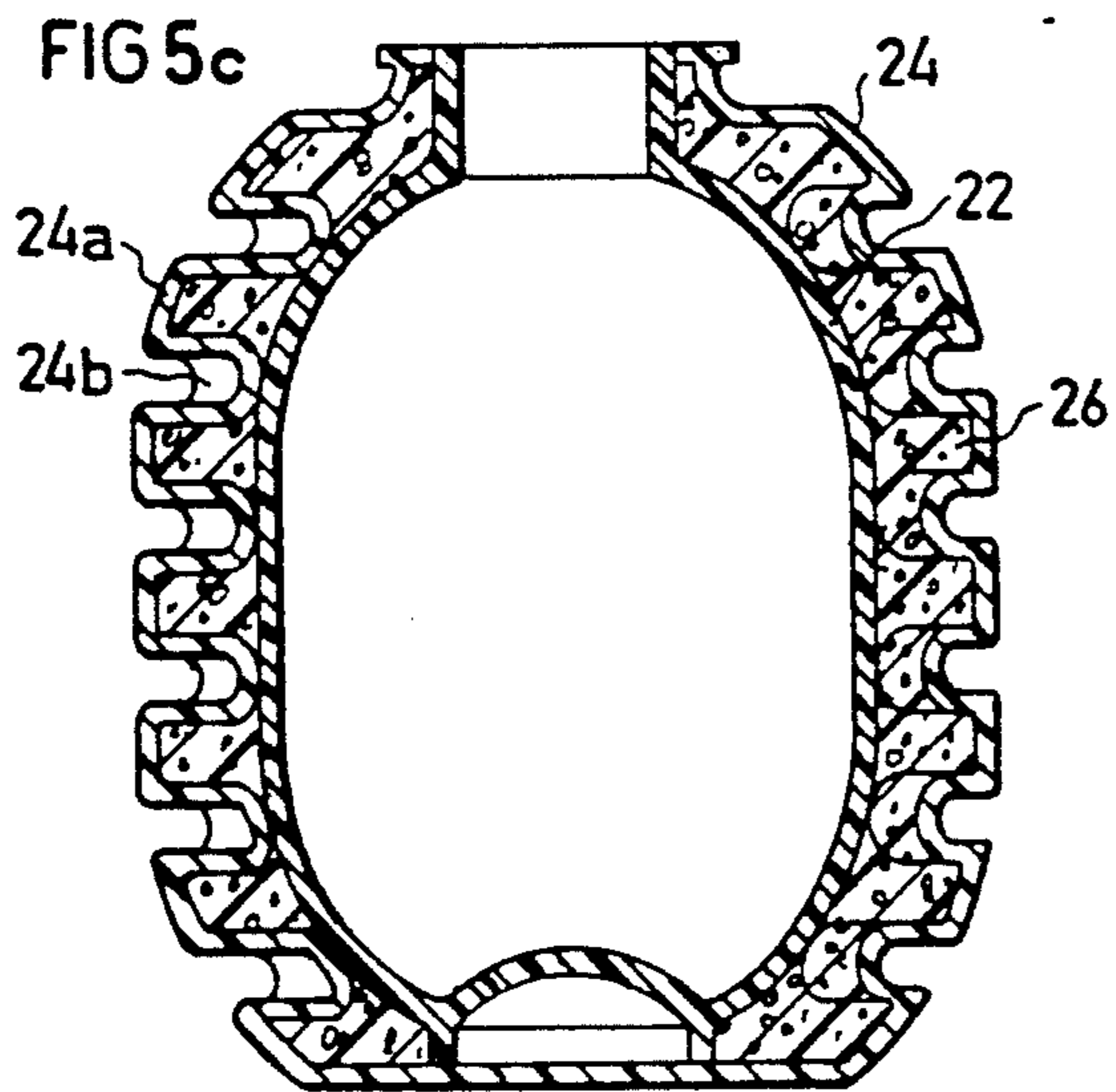
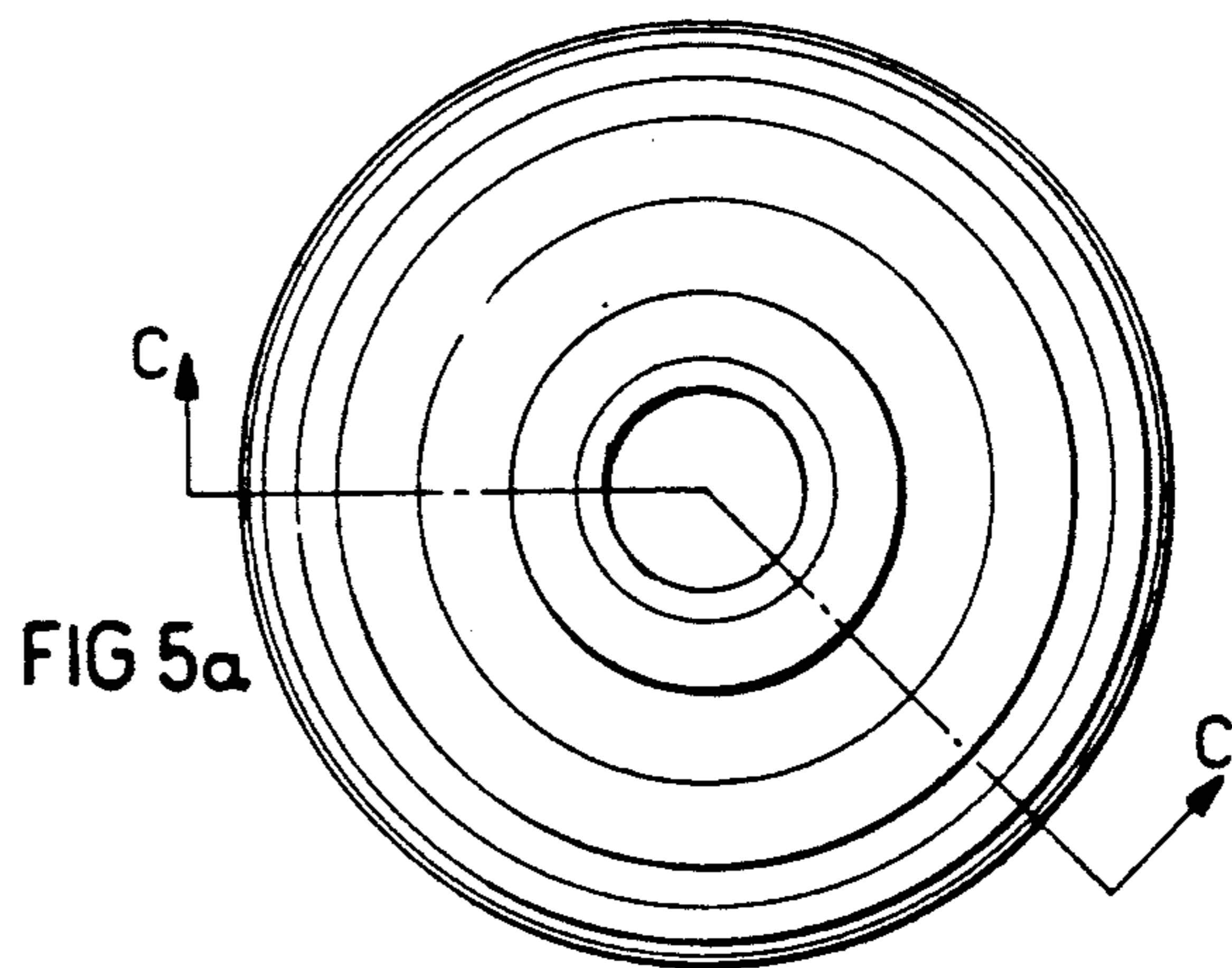
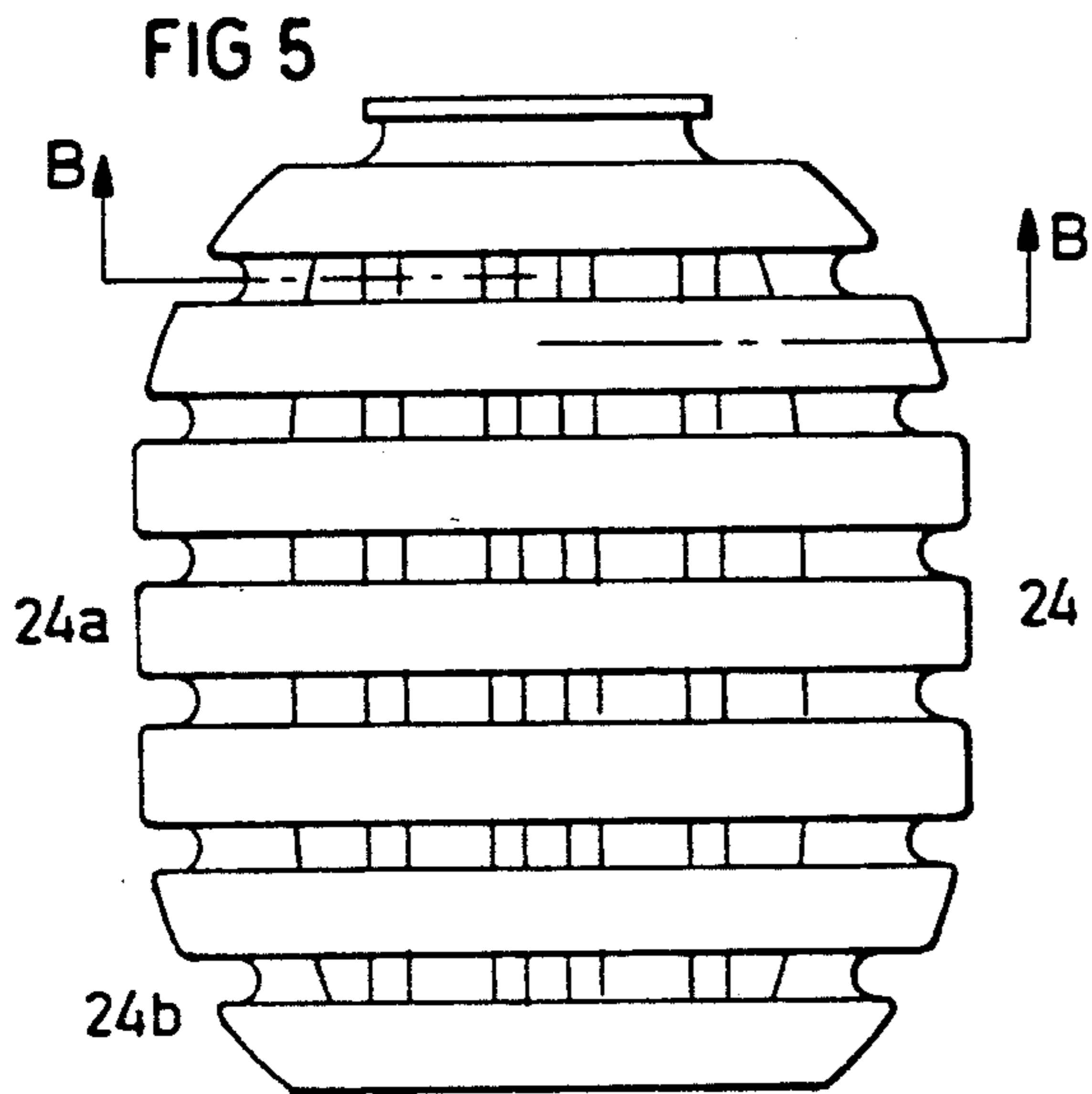
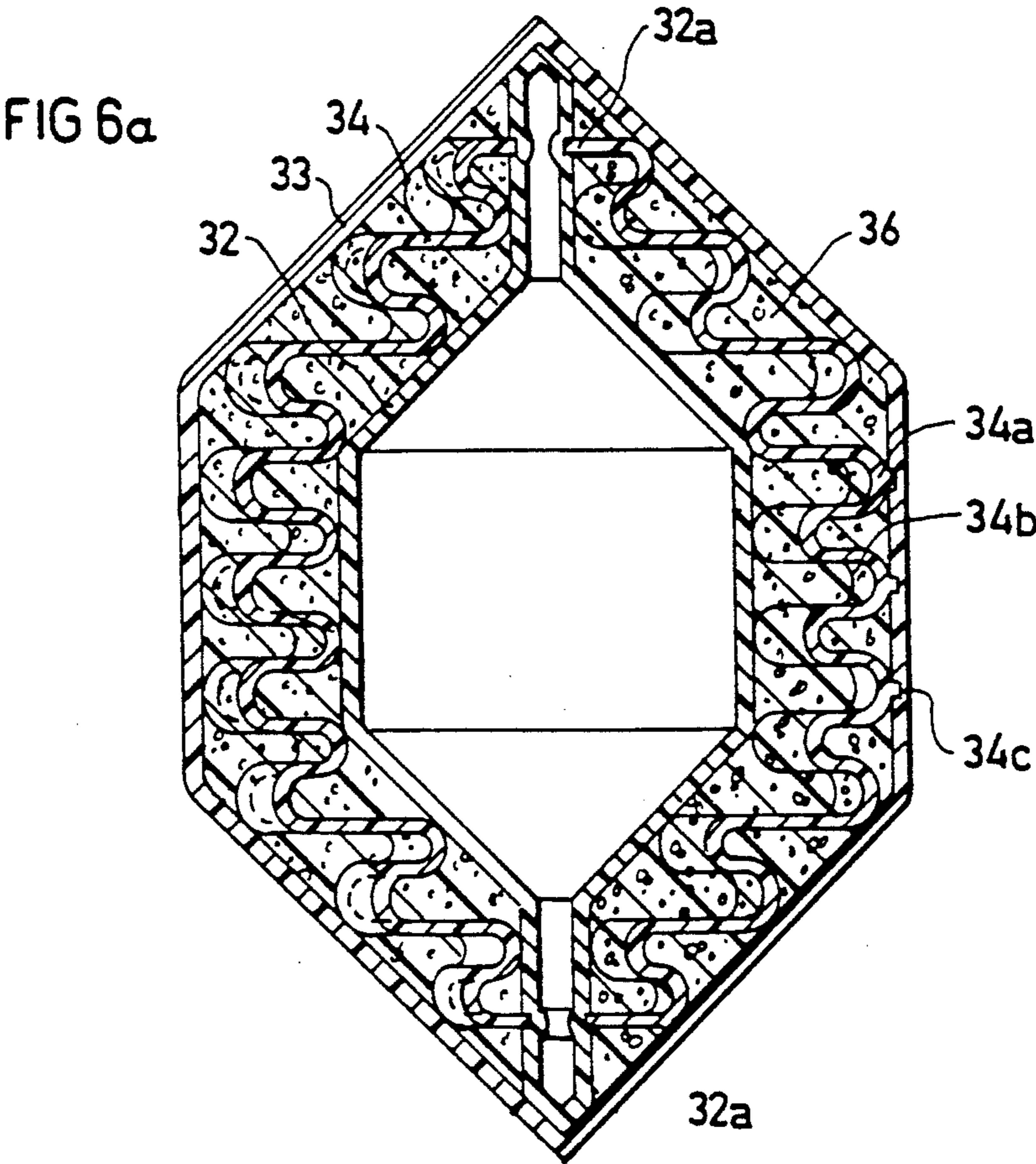
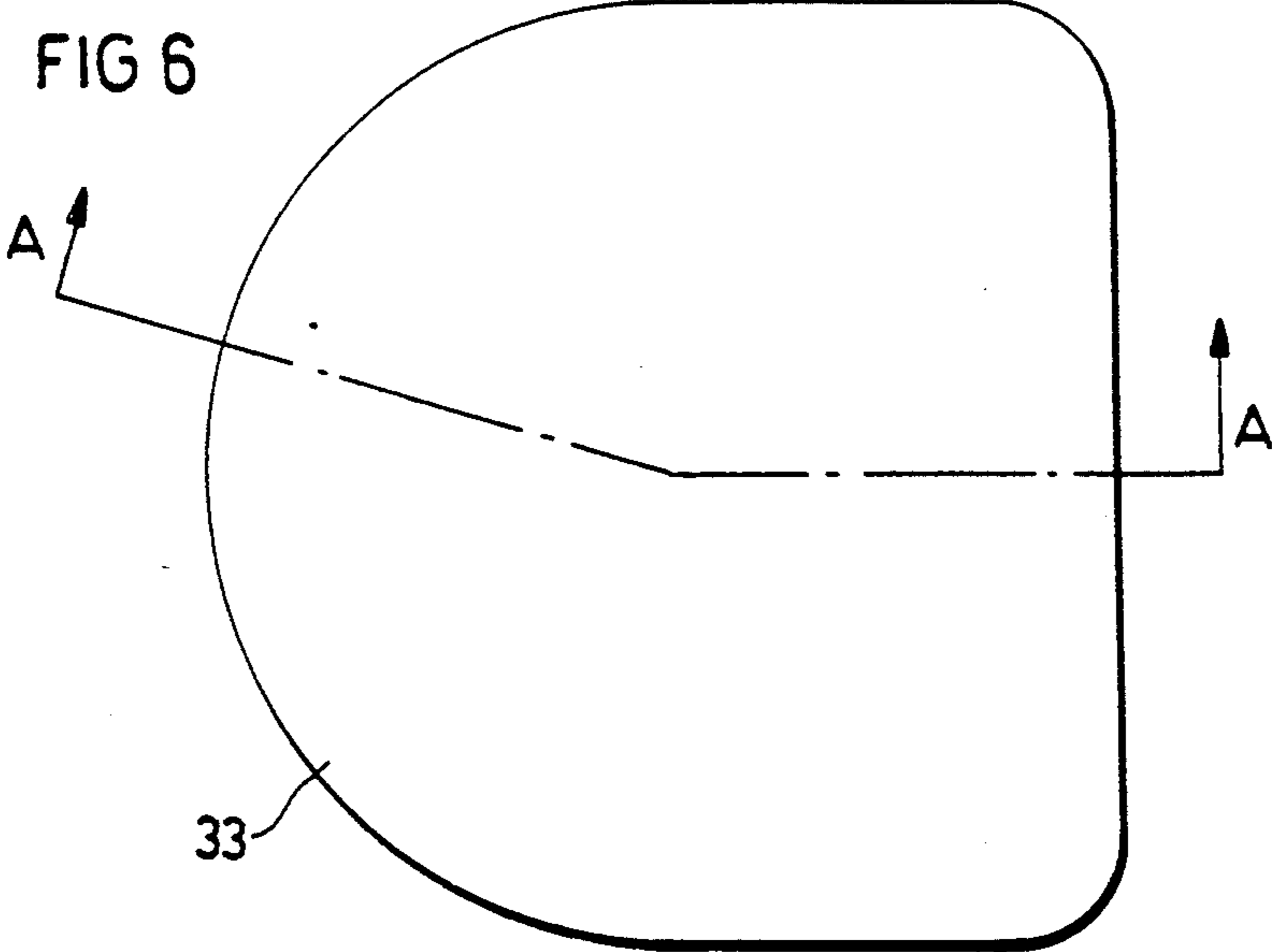


FIG 4a







MULTIPLE-WALL PLASTIC CONTAINER AND METHOD OF MAKING SAME

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to containers, and particularly to plastic containers capable of withstanding high internal or external pressures both in the axial direction as well as in the radial direction.

Containers (which expression also includes vessels, housings, tanks, etc.), particularly large constructions useful for containing liquids or gasses under high pressure, are at the present time usually built of metal and/or laminated composite materials because of the high resistance required in order to withstand high axial and radial pressures. Containers made of metal are very time-consuming and costly to build because of the need first to produce the various components of the container and then to assemble them together, e.g., by welding. Moreover, a high degree of expertise is required because if the welding (or other bonding technique) used for assembling the components together is not perfectly executed, leaks may develop during the use of the container. Further, metal containers tend to corrode, oxidize, pit or develop unpleasant odours or tastes, unless non-corrosive metals are used, such as stainless steel, or protective layers or coatings are applied, both of which substantially increase the expense and/or time in producing the containers. Building containers made from laminated composite materials is also time-consuming, expensive and expertise-dependent because of the need to manufacture the components and then assemble them together.

OBJECTS AND BRIEF SUMMARY OF THE PRESENT INVENTION

An object of the present invention is to provide a plastic container particularly useful for containing liquids or gasses under high-pressure and having advantages in the above respects. Another object of the invention is to provide plastic containers having very high strength relative to their weight and cost; and a further object of the invention is to provide a method of making the novel plastic containers.

According to the present invention, there is provided a high pressure plastic container comprising a first wall of moulded plastic material closed at the bottom and open at the top; and a second wall of moulded plastic material closed at the bottom and open at the top, and bonded to the first wall. One or both of the walls are integrally formed with a plurality of ribs of a hollow construction.

According to a further feature in the preferred embodiments of the invention described below, the hollow ribs are filled with a rigid plastic foam, which binds the two walls together to form an integral multiple-wall construction of very high strength.

The multiple-wall plastic containers may be produced by rotational moulding. Rotational moulding is a low-pressure process in which the strength required from the mould is minimal. The rotational mould may therefore be constructed of thin metal or plastic, so that the tooling costs are only a small fraction (usually less than one-fifteenth) the cost of a conventional injection-mould. A further advantage in using rotational moulding is that this low-pressure process produces parts which are relatively stress free, as compared to high-

pressure injection moulding processes. This advantage is particularly important since it enables the production of very large containers of various configurations, such as spherical, cylindrical, ellipsoidal, conical, and almost any other desired configuration, having substantially stress-free walls, very high strength relative to weight and cost and very high resistance to internal and external forces applied radially as well as axially.

Thus, the radial strength of a container is usually in the order of 50% its axial strength; but by providing the above-described hollow ribs, the radial strength can be increased to be substantially equal to the axial strength of the container. In addition, such a multiple-wall container can be produced in a fraction of the time normally required for producing comparable containers from metal or from laminated composite material. Further, such multiple-wall plastic containers can use different materials for the two walls to provide maximum strength as well as maximum resistance to corrosion, oxidation, pitting, or the development of unpleasant odours or tastes.

In producing such a multiple-wall plastic container, each wall is preferably made by a one-shot rotationally-moulding process, in which each wall is made as a continuous and integral shell. Thus, the inner wall is first produced by rotational moulding so as to be closed at its bottom and open at its top; and then the second wall is produced by rotational moulding directly around the inner wall. The plastic foam is then introduced into the space between the two walls to fill the hollow ribs and to integrally bond the two walls together, to thereby produce an integral honeycomb structure that is light and strong relative to its weight and cost.

Several embodiments of the invention are described below for purposes of example.

In one described embodiment, one of the plastic walls is integrally formed with circumferentially-extending axially-spaced hollow ribs, and the second wall is integrally formed with a plurality of axially-extending circumferentially-spaced ribs directly over the inner wall. Both the circumferentially-extending ribs of one wall and the axially-extending ribs of the other wall are of U-shaped cross-section such that the two groups of ribs cross each other substantially at right angles to produce a two-dimensional matrix or honeycomb structure which is subsequently filled with the rigid plastic foam.

A second embodiment is described below wherein one of the walls, e.g., the inner wall, is unribbed so as to provide a smooth inner surface.

A third embodiment of the invention is described below wherein one of the walls (e.g., the inner wall) is unribbed, and the other wall (e.g., the outer wall) is integrally formed with both circumferentially-extending, axially-spaced hollow ribs, and axially-extending, circumferentially-spaced hollow ribs.

A fourth embodiment of the invention is described wherein the container is made of three walls, namely an inner unribbed (smooth) wall, a middle wall formed with the above-described ribs, and an outer unribbed (smooth) wall.

Further embodiments, features and advantages of the invention will be apparent from the description below.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

FIGS. 1 and 1a are side and plan views, respectively, illustrating one form of multiple-wall plastic container constructed in accordance with the present invention, FIG. 1b being a sectional view along line b—b of FIG. 1a;

FIGS. 2 and 2a are side and plan views, respectively, illustrating the construction of the inner wall in the container of FIG. 1; FIG. 2b is a sectional view along line b—b of FIG. 2, and FIG. 2c is a sectional view along line c—c of FIG. 2b;

FIGS. 3 and 3a are side and plan views, respectively, illustrating the mould during its use in the production of the outer wall of the container of FIG. 1; FIG. 3b being a sectional view along line b—b of FIG. 3a;

FIG. 4 is a side elevational view illustrating a second multiple-wall plastic container constructed in accordance with the invention, FIG. 4a being a sectional view along line a—a of FIG. 4;

FIGS. 5 and 5a are side and plan views, respectively, illustrating a third multiple-wall plastic container constructed in accordance with the invention; FIG. 5b is a sectional view along line b—b of FIG. 5; and FIG. 5c is a sectional view along line c—c of FIG. 5a; and

FIG. 6 is a plan view illustrating a fourth multiple-wall plastic container constructed in accordance with the invention, FIG. 6a being a sectional view along line a—a of FIG. 6.

DESCRIPTION OF PREFERRED EMBODIMENTS

The Embodiment of FIGS. 1-3

FIGS. 1-3 illustrate a plastic container constructed of an inner plastic wall, generally designated 2, and an outer plastic wall, generally designated 4, both made by a rotational-moulding process, in which the inner wall 2 is first produced, and then the outer wall 4 is produced directly over the inner wall 2. FIGS. 2 and 2a-2c more particularly illustrate the structure of the inner wall 2, and FIGS. 3, 3a and 3b illustrate the construction of the rotational-mould for producing the outer wall 4 over the inner wall 2.

The inner wall 2 is integrally formed with a plurality of axially-extending circumferentially-spaced hollow ribs 2a. As shown particularly in FIG. 2b, each rib 2a is of a U-shaped configuration to provide a space 2b between the two legs of the rib; and the ribs are joined together by web portions 2c of smaller diameter than the ribs 2a such that the ribs 2a radiate outwardly from the web portions 2c of wall 2. As shown particularly in FIG. 2c, wall 2 is closed at one end by a curved bottom wall 2d, and is open at its opposite end by a cylindrical wall 2e. The closed bottom wall 2d is circumscribed by an axially-extending flange 2f formed with a plurality of axially-extending slots 2g, for a purpose to be described below.

The outer wall 4 is formed with a plurality of circumferentially-extending axially-spaced ribs 4a which cross ribs 2a at right angles. Ribs 4a are also of U-shape cross-section to provide a space 4b between the two legs of each rib, and are also joined together by a web portion 4c which is of smaller diameter than the ribs 4a so that the ribs project outwardly from the web portion of wall 2. The spaces between the legs of the ribs 2a and 4a thus interconnect and form interconnecting conduits. These interconnecting spaces or conduits are filled with a rigid plastic foam 6 which binds the two walls and produces therewith a two-dimensional honeycomb structure substantially increasing the structural strength of the con-

tainer with respect to both radial forces as well as axial forces.

The outer wall 4 is closed at one end by bottom wall 4d which is spaced from the curved bottom wall 2d of the inner wall 2. The opposite end of wall 4 is open and is formed with an annular lip 4e which engages the outer surface of the cylindrical opening 2e of inner wall 2. The bottom wall 4d is further provided with one or more openings 4f inwardly of axial flange 2f formed in the inner wall. Openings 4f serve as inlet ports for injection the rigid plastic foam into the spaces between the two walls 2, 4; and the slots 2g in the axial flange 2f of the inner wall permit the injected plastic foam to fill all the spaces between the two walls, including the space between the two bottom walls 2d, 4d and the spaces between the plurality of ribs 2a, 4a, of the two walls.

Each of the two walls 2, 4, is produced by a one-shot rotational-mould process. In each case, the rotational mould is a shell-type mould that defines the outside shape and surface of the respective wall. The inside surface of the respective wall is defined by the outside shape and the wall thickness.

Thus, since the inner wall 2 is formed with a plurality of axially-extending, circumferentially-spaced hollow ribs 2a, the cavity of the rotational mould used for producing the inner wall 2 would be formed with complementary axially-extending, circumferentially-spaced recesses; and since the outer wall 4 is formed with a plurality of axially-extending, circumferentially-spaced ribs 4a, the cavity of the mould for producing that wall would be formed with a plurality of complementary axially-extending, circumferentially-spaced recesses. The mould for producing the outer wall 4 is more particularly seen in FIGS. 3, 3a and 3b, wherein it is generally designated 10; and while the construction of the mould for producing the inner wall 2 is not shown in the drawings, its construction will be apparent from the description below of mould 10.

Thus, in order to produce the double-wall construction illustrated in FIGS. 1, 1a and 1b, the inner wall 2, as illustrated in FIGS. 2 and 2a-2c, is first produced by rotational moulding. For this purpose, a measured amount of plastic material to be used for producing wall 2 is placed, in powder or liquid form, in the cavity of a rotational mould, having a cavity corresponding to the outer surface of the wall 2 to be produced, as described above, and the mould is closed. The mould is then placed into an oven where it is continuously rotated about both its vertical and horizontal axes as the mould is heated. The biaxial rotation of the mould causes the plastic material within it to come into intimate contact with all the surfaces of the mould cavity. The biaxial rotation continues until all the plastic material has been melted so as to completely cover the mould cavity and to form a uniform layer of melted plastic.

While the biaxial rotation continues, the mould is moved out of the oven into a cooling chamber where air, or a mixture of air and water, cools the mould and the layer of molten plastic material within it until the plastic layer sufficiently hardens so as to retain its shape.

The so-produced inner wall 2 is then removed from the mould and placed into the outer mould 10 for producing the outer wall 4. FIGS. 3, 3a and 3b more particularly illustrate the construction of the outer mould 10, wherein it will be seen that the inner surface of the mould, defining the cavity, is shaped so as to conform to

the outer surface of the outer wall 4 to be integrally formed on the inner wall 2.

Thus, mould 10 is formed with a plurality of circumferentially-extending axially-spaced recesses 10a to produce the ribs 4a in wall 4, the spaces 4b between the two legs of each rib, and the web portions 4c connecting the ribs together. Mould 10 is dimensioned so that its inner face thus conforms to the outer face of wall 2, and is spaced from the previously-formed inner wall 2 by the intended thickness of the outer wall 4.

As shown particularly in FIG. 3a, mould 10 is made of two sections that come together along a longitudinally-extending parting line 10b. In addition, the upper end of the mould is provided with a top wall 10c closing the open end of the inner wall 2, and with three locating pins 10d engageable with the inner face of the cylindrical wall 2e at the open end of that wall. The bottom end of the mould is similarly provided with a bottom wall 10e and with a plurality of locating pins 10f engageable with the inner surface of the axial flange 2f of the inner wall 2. Preferably, the top and bottom walls 10c, 10e, and the locating pins 10d, 10f, are made of a material which is non-adherent to the plastic material being moulded. For example, the latter parts may be made of, or coated with, a fluoroethylene polymer or a silicone.

The top mould wall 10c closes the open end of the inner wall 2 and prevents plastic material from entering the interior of that wall when the outer wall 4 is moulded around the inner wall 2. The bottom mould wall 10e is spaced from the outer edge of the axial flange 2f of the inner plastic wall 2, so as to define the space for producing the bottom of the outer plastic wall 4; and the bottom pins 10f define the openings 4f through the bottom plastic wall 4d for subsequently introducing the rigid plastic foam 6 binding the two plastic walls together. Locating pins 10d and 10f may be retained in their respective mould walls by retainer pins 10g, 10h.

The outer wall 4 is rotationally moulded within mould 10 in the same manner as described above with respect to the inner wall 2. After the outer wall 4 has been moulded integral with the inner wall 2, the two plastic walls are removed from the mould, and a plastic foam is injected, via openings 4f (FIG. 1b) through the bottom 4d of the outer plastic wall 4. The plastic foam fills the space between the two bottom walls 2d, 4d, and flows through the slots 2g so as also to fill the remaining spaces between the two walls, including the spaces between the hollow ribs 2a and 4a.

The two walls 2, 4, may be made of any suitable plastic material which can be caused to flow (e.g., by heating) and which hardens so as to retain its shape. Each wall can be produced from a different plastic material to maximize the desired characteristics of such materials, with respect to ease of moulding, mechanical strength, melting temperature, inertness to various chemicals, environmental resistance to weather and soil, etc.

The rigid plastic foam injected into the spaces between the two walls may also be of any suitable material, such as polyurethane. The rotational moulds for producing the inner wall 2 and the outer wall 4 may be of any suitable material, such as steel, aluminum, stainless steel sheet metal, electroformed nickel, etc. Where the moulding is to be effected at relatively low temperatures, e.g., room temperature, a thermosetting polymer, e.g., polyester, epoxy resin, silicone rubber, or impregnated fibreglass may be used for the moulds.

The Embodiments of FIGS. 4 and 4a

FIGS. 4 and 4a illustrate a double-wall plastic container in which the inner wall, therein designated 12, is unribbed; that is, both its inner and outer surfaces are smooth. In all other respects, the inner wall 12, and the outer wall 14, are of the same construction, and are made in the same manner, as described above with respect to the embodiment of FIGS. 1-3.

In the embodiment of FIGS. 4 and 4a, the space between the two walls 12, 14, is also preferably filled with a rigid plastic foam 16. This may be done by providing openings in the bottom of the outer wall 14e, as shown at 14f in FIG. 4a, for injecting the plastic foam, and also corresponding openings (not shown) in each of the ribs 14a of the outer wall 14; alternatively, communication may be provided in the spaces between all the ribs with the space between the bottom 14d and 12d of the outer wall 14 and inner wall 12 by forming one or more axially-extending grooves (not shown) in the outer face of the inner wall web portions 12c, or in the inner face of the outer wall web portions 14c.

The construction illustrated in FIGS. 4 and 4a is particularly useful where sufficient mechanical strength is obtained by only the circumferentially-extending grooves 14, and where the nature of the contents of the container is such that it is preferred that the container have an inner smooth surface.

The Embodiment of FIGS. 5 and 5a-5c

FIGS. 5 and 5a-5c illustrate a double-wall plastic container which is also constructed of an inner wall 22 and outer wall 24 integrally joined together by a rigid plastic foam 26. In this container, the inner wall 22 is also unribbed (as inner wall 12 in the FIGS. 4, 4a embodiment), but the outer wall 24 is formed with biaxial ribs, namely with a plurality of circumferentially-extending, axially-spaced ribs 24a, and also with a plurality of axially-extending, circumferentially-spaced ribs 24b. The bottoms of the two walls 22, 24 are formed in the same manner as described above. Also, openings, corresponding to openings 14f (FIG. 4a) or 4f (FIG. 1b), are formed for injecting the rigid plastic foam between the two walls in order to fill the spaces defined by the ribs and to bond the two walls together and thereby to produce an integrated wall structure having the ribs 24a, 24b extending along both axes. It will be appreciated that the axially-extending ribs 24b provide communication 28 between the circumferentially-extending ribs 24a, permitting the rigid plastic foam to be injected in a one-shot manner, as described above with respect to the embodiment of FIGS. 1-3.

In all other respects, the container illustrated in FIGS. 5 and 5a-5c is constructed in the same manner as described above.

The Embodiments of FIGS. 6 and 6a

FIGS. 6 and 6a illustrate a multiple-wall plastic container including three walls, namely an inner wall 32, an outer wall 33, and an intermediate wall 34. Both the inner wall 32 and the outer wall 33 are unribbed, whereas the intermediate wall 34 is formed with the hollow ribs enhancing the mechanical strength of the container. In this case, the intermediate wall 34 is formed with the biaxial ribs similar to the FIG. 5 embodiment, that is with both circumferentially-extending, axially-spaced ribs 34a, and axially-extending, circumferentially-spaced ribs 34b. In addition, the spaces between these ribs are completely filled with the rigid

plastic foam 3 thereby firmly bonding all three walls together to produce an integrated, honeycomb wall structure containing the biaxially-extending ribs.

In the biaxial-rib construction illustrated in FIG. 6a, the rigid plastic foam may be introduced via openings formed in the bottom wall, similar to the FIGS. 1-3 and FIG. 5 embodiments, since the axially-extending ribs provide communication between the circumferentially-extending ribs. If, however, the intermediate wall 34 is provided only with circumferentially-extending ribs, the plastic foam would be introduced in one of the manners described above with respect to the FIGS. 4, 4a embodiment. If wall 34 is provided only with axially-extending ribs, the plastic foam could also be introduced from the bottom in the same manner as described above.

When a three-wall construction is to be produced as illustrated in FIGS. 6 and 6a, each of the three walls would be produced in a separate rotational-moulding step. The inner wall 32 would be a single continuous wall, as illustrated in FIG. 6a, and could take the quasi-hexagonal configuration as illustrated in FIG. 6a, or any other suitable configuration. The intermediate wall 34 is preferably constructed of two sections on opposite sides of the inner wall 32, with the end of each section received in a recess as shown at 32a in FIG. 6a, formed in the inner wall 32. The two sections of the intermediate wall 34 could be further formed with projections as shown at 34c, received within recesses formed in the outer wall 33 in order to firmly anchor the intermediate wall sections 34 between the two walls 32, 33, particularly when the rigid plastic foam is injected between the two walls.

Other Variations

While the invention has been described with respect to several preferred embodiments, it will be appreciated that many other variations may be made. For example, in the FIGS. 1-3 embodiment, the circumferentially-extending ribs may be formed on the inner wall (e.g., when the container is used for a pressurized gas), and the axially-extending ribs may be formed in the outer wall. In the FIG. 4 embodiment, the outer wall 14 may be formed with axially-extending, circumferentially-spaced ribs, rather than with circumferentially-extending, axially-spaced ribs; also, the ribs may be formed in the inner wall, rather than in the outer wall, particularly when the container is to be used for a pressurized gas. Similarly, in the FIG. 5 embodiment, the biaxially-extending ribs may be formed in the inner wall, rather than in the outer wall. Further, in the FIG. 6 embodiment, as well as in the other described embodiments, the anchoring of one wall to the other or others may be effected by producing a shrink-fit of one wall on the

other, by heat fusion, or the like. It will also be appreciated that containers of other configurations may be produced according to the invention.

Many other variations, modifications and applications of the invention will be apparent.

What is claimed is:

1. A high pressure plastic container, comprising: wall means including a first wall of moulded plastic material closed at the bottom and open at the top; and a second wall of moulded plastic material closed at the bottom and open at the top, and bonded to said first wall; said wall means being formed with a first plurality of circumferentially-extending axially-spaced hollow ribs and with a second plurality of axially-extending circumferentially-spaced hollow ribs disposed substantially perpendicularly to said first plurality of hollow ribs.
2. The container according to claim 1, wherein one of said walls is formed with said circumferentially-extending, axially-spaced hollow ribs, and the other of said walls is formed with said axially-extending, circumferentially-spaced hollow ribs.
3. The plastic container according to claim 1, wherein said first wall is integrally formed with said plurality of circumferentially-extending axially-spaced hollow ribs, and also with said plurality of axially-extending, circumferentially-spaced hollow ribs.
4. The container according to claim 3, wherein the other of said walls is unribbed.
5. The container according to claim 4, wherein the unribbed wall is the inner wall of the container, and the ribbed wall is the outer wall of the container.
6. The container according to claim 3, wherein said wall means includes a third wall of plastic material enclosing and bonded to said second wall.
7. The container according to claim 6, wherein said second wall is between said first and third walls and is formed with all said hollow ribs, the spaces between said three walls all being filled with a plastic foam.
8. The container according to claim 1, wherein the innermost wall is formed with an inwardly curved closed bottom.
9. The plastic container according to claim 1, wherein said first and second walls are made of different plastic materials.
10. The plastic container according to claim 1, wherein each of said hollow ribs is of substantially U-shape in cross-section.
11. The container according to claim 1, wherein said hollow ribs are filled with a rigid plastic foam.

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